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ANALYSIS OF A PART USING DYNAMIC SIMULATION AND REAL TIME EXPERIMENTS IN PART FEEDERS

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ABSTRACT

In the modern industrial world, agility in manufacturing and assembly line is the key for improving the productivity. Segregation and feeding of parts in assembly line is important for reducing the manufacturing lead time. The segregation and feeding of parts are either done manually, which is a time consuming work or by installing robots with machine vision system, which is costly. To overcome this problem, Part feeders are used for feeding the parts in a single orientation. Trap is a system which changes the orientation of part and stores the part in an expected orientation. The objective of this work is to explore the real time monitoring and dynamic simulation of the trap in a part feeding system. An experimental setup fabricated to perform vibration analysis on the trap. The vibration analysis will help in determining the various frequency levels by conducting various trails during experiments. The work includes multi body dynamic simulation for a part on the trap. It helps to study the dynamics of moving parts in a trap. In this paper, a comparison is made between dynamic simulation and real time experiments, the outcomes show that there are strong similarities between the results of dynamic simulation and real time experiments.

Keywords: Brake Pad, Trap, Part Feeders, Dynamic Simulation and Vibration Analysis

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Original Article

1. INTRODUCTION

Part feeders are devices which obtains a relatively large quantity of differently oriented objects at its input side & the output being the same parts in the desired orientation at its output. Vibratory feeders are defined as the instruments which make use of vibrations in order to feed the materials onto a particular process. In addition to the use of vibrations to move the material, gravity is also used. Briefly, the material is moved with the help of vibration and the direction is determined with the help of gravity. The major use of such a device is to transfer a huge amount of small sized objects. Vibratory feeders are incorporated with passive and active devices to present the part in the desired orientation for further assembly. The sequence of the placement of active and passive devices depends on the orientation of the material to be obtained as output [1]. The component which is considered here for the trial is the brake pad which is known for its irregular shape and structure. They pose a challenge for orientation as they have more than one stable configuration. Trap is the heart of the part feeding system to change possible orientations to natural resting orientation. For designing the trap, the natural resting orientation or favorable orientation of a component must be understood. The favorable orientation of the part is the one in which the part rests on a horizontal surface which is identified using a drop test. By dropping a part from different

heights, the orientation of the part is noted after it comes to rest. The most probable occurrence of orientation is considered as favorable orientation of part [2]. The trap is designed by taking the favorable orientation under consideration. Berkowitz, et al [3] described how dynamic simulation was used to hasten the part feeder's prototype and design. An industrial vibratory bowl feeder was used to compare the simulated and physical experiments and it was discussed along with the probabilistic description of the behavior of vibrating part feeders. In this work, dynamic simulation and physical experiments are made using part feeders for asymmetric parts like brake pad.

2. RELATED WORK

Dan Reznik et al [4] analyzed Novel planar part feeders' part motion which is dynamic consists of a longitudinal flat plate which vibrates and also includes a part which is placed on its own surface. The forward motion of the velocity of the plate is dominating (i.e) held positive for a longer time than the backward motion (negative). The result obtained from the dynamic simulation of rigid body tends to be in a better agreement with the analysis made. Kothandaraman et al [5] presented the practical implementation of feedback control strategy to a laboratory scaled vibration isolator platform. LabVIEW simulation is the one which is used to develop the test rig which is laboratory scaled. It is also interfaced via a PC with an applicable data acquisition card which acts as the main controller. The system is then checked for its robustness by applying the suitable vibration source to the system which is proposed. Lita et al [6] presented a novel implementation of a general purpose monitoring and analysis system for mechanical vibrations. The main parts of the system are data acquisition board connected to a personal computer, the vibration sensors, and the analysis and control software which in this case is realized in LabVIEW graphical programming environment.

The vertical vibration of mill stand was simplified by Lijuan Zhao et al [7] to six DOF spring-mass dissymmetric system. ADAMS which is a mechanical dynamics analysis software was used to build a protyping model which was based on simplified model. One of the modules of ADAMS, 'ADAMS/vibration' was used to calculate the mode shape and undamped natural frequency, in this study. The investigation for the purpose of automated assembly by using vibratory bowl feeders was done by Silversides et al [8] lead to the dynamic modeling of vibratory feeder by presenting a geometric model of the feeder and developing the force analysis for the same model. The Dynamic model includes the integration of the bowl's angular displacement with the leaf-spring legs' displacement. The technology of Virtual prototyping was used as the base for the proposal of the simulation method for vibration analysis which was to improve the performance of high speed, high precision, high power robots which was the aim of leu et al [7]. ADAMS/Vibration was used to establish a spot welding robot's coupling vibration system which is rigid and the frequency response under certain forced vibration was calculated. In this work, ADAMS/Vibration is used to analyze the part motion in a trap. The physical experiments are to be conducted by using LabVIEW software. Finally the outcomes of dynamic simulation and physical experiments will be compared.

3. EXPERIMENTAL METHODOLOGY

The methodology used for finding the best parameters like frequency, trap angle and track angle is shown in the Figure 1. For these best values, mechanical analysis and Mechatronics analysis is carried out. (In a mechanical system analysis, the dynamic simulation methods are used where in mechatronics system analysis, the real time experiments are carried out to find the optimum parameters)

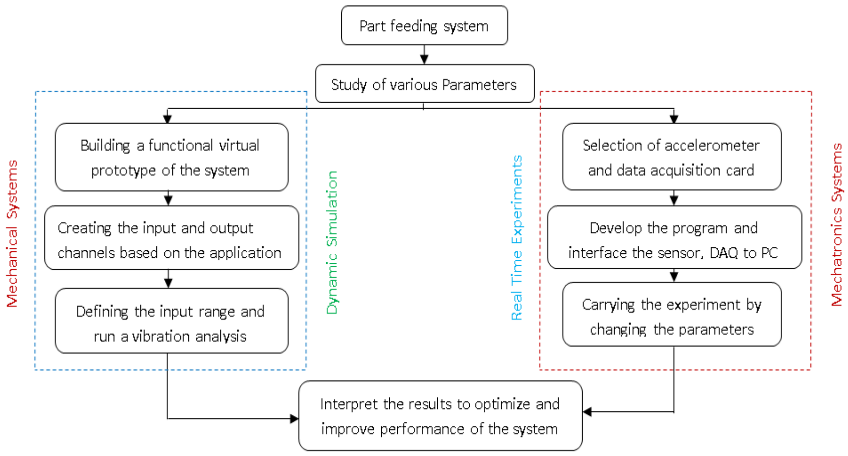

Figure 1: Methodology

This experimental methodology will be discussed in forth coming sections 3.1 and 3.2. The outcome of this analysis will be discussed in section 4.

3.1. Dynamic Simulation

The modeling of the trap is done and the behavior of the respective part is checked with the help of dynamic simulation using ADAMS computer program. Various operating points which are obtained is used by the system to analyze the trap's vibratory behavior. Shown in Figure 2.

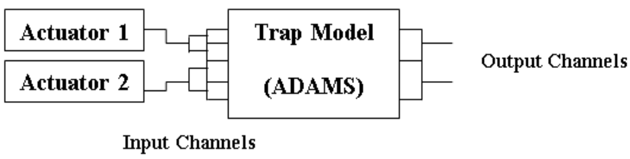

Figure 2: Model Development in ADAMS

The input channels and vibration actuators are added to the trap for vibrating the system. The output channels are added to measure the response shown in figure 3. Two input channels at the global x and y directions of the vibration actuators are created.

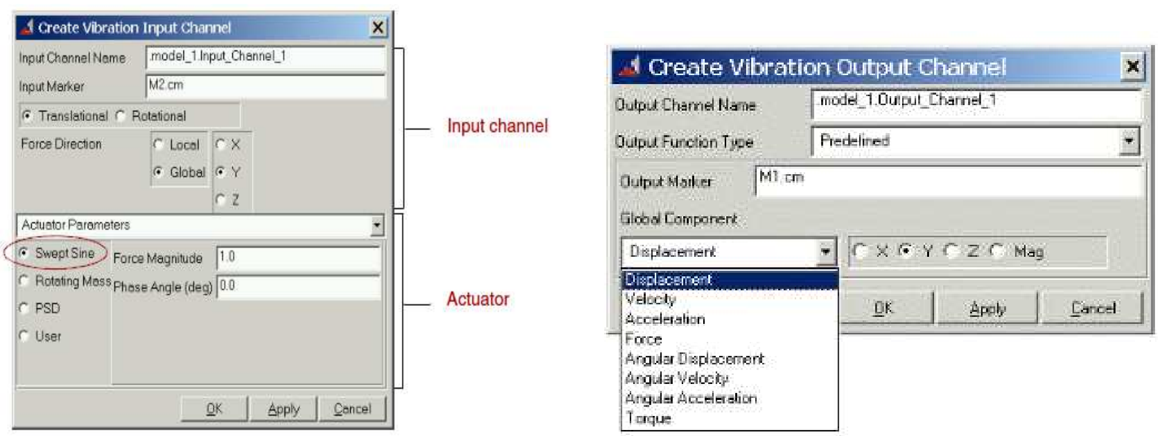

Figure 3: Creating Input and Output Channels

Output channels are output ports at which the frequency response of the system is examined. Output channels are instrumentation ports to measure system response and report the results directly in the frequency domain. The input range is defined and a vibration analysis will be run to obtain free and forced vibration responses. The force added in the lateral direction and the transmitted accelerations are checked. The forced vibration analysis procedure shown in figure 4.

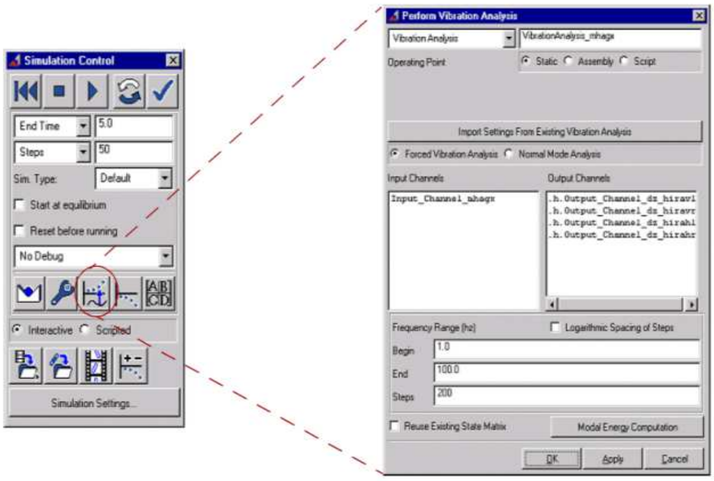

Figure 4: Forced Vibration Analysis

The forced vibration analysis sets up the vibration reference configuration for the model. When a vibration analysis is created, Adams/Vibration designates input and output locations. These locations are used when the vibration analysis is performed. Adams/Vibration automatically performs a normal modes analysis before performing a forced vibration analysis.

3.2. Real Time Experiments

The experimental setup to measure acceleration on part feeders is shown in figure 5. A 3 axis accelerometer is used to measure G-forces in trap while the part moves on it. Trap is a system which is used to convert favorable orientation of a part into most favorable one. Here brake pad is used for the experiment. Trap and vibrator is connected by using trap fixture. This trap fixture is specially designed for this particular trap. Trap fixture have two inclination angles i.e. trap angle and track angle. Angle between the base plate and middle plate is a trap angle and angle between a middle plate and top plate is a track angle. These angles are shown in figure 6.

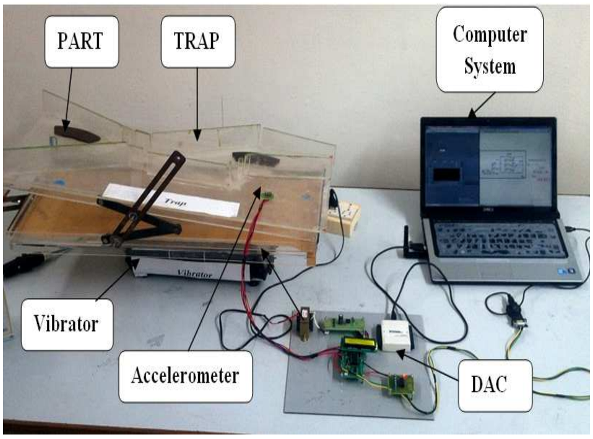

Figure 5: Experimental Setup

The vibration's frequency is controlled with the help of a vibrator controller which has a vibrator connected to it. Accelerometer is pasted on trap and its wires connected to DAC (NI USB-6009). Finally DAC is interfaced with personal computer. The output of the acceleration will be monitored by computer system.

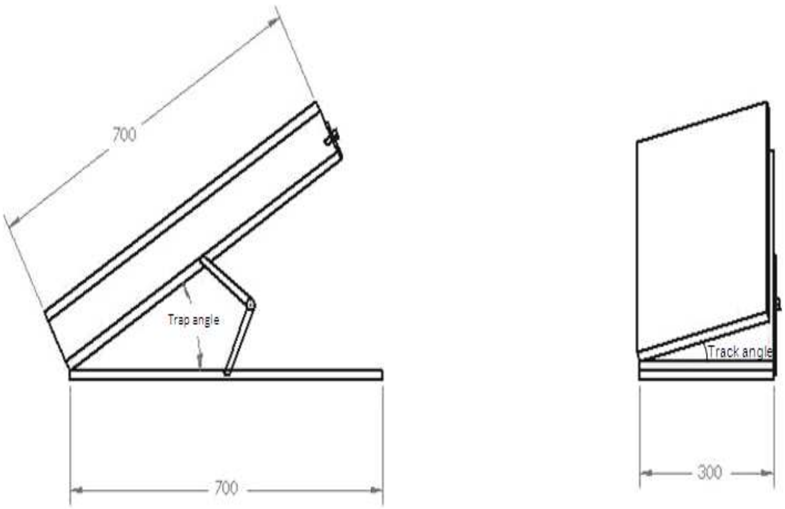

Figure 6: Trap Fixture

The user interface was created so that the system has a numeric control for the sensitivity setting of the accelerometer, a numeric control for the nominal voltage output at zero-g acceleration and a waveform chart indicator to display the acceleration values. The block diagram is shown in the figure 7.

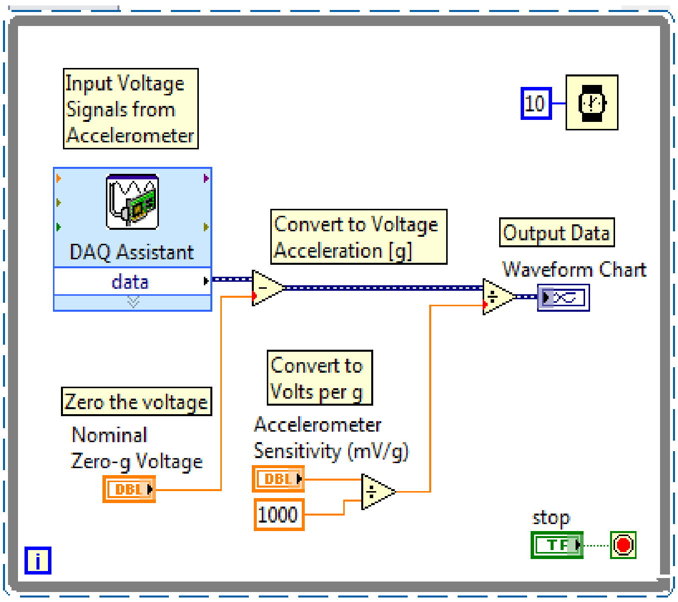

Figure 7: Lab VIEW Block Diagram

On the block diagram, the data is fed as input using the DAQ Assistant. The values are read and the nominal zero-g voltages offset are subtracted as specified. The nominal zero-g voltage can be given as input signal on the front panel. Then the voltage value is converted to an acceleration value by dividing the sensitivity in V/g. This sensitivity is fed as input to the front panel. The resulting value will be the acceleration in g, from -1.5g to +1.5g, which we can then wire to a waveform chart to display the values on the front panel.

4. RESULTS AND DISCUSSIONS

In this section the outcome of the dynamic simulation and real time experiments will be discussed.

4.1. Dynamic Simulation Results

The functional virtual prototype of the trap connected with trap fixture is efficiently built using ADAMS/View as shown in figure 8. The vibration behavior of the part motion is analyzed by taking various operating points of the system. ADAMS/view was used to build the part which is used for the analysis, given that the part which is the brake pad is an irregular component. The frequency trap angle, track angle are the three major factors which determines the movement of the part on the trap. The above parameters are varied in order to obtain different part motion. The set of values of those parameters which provides the best part motion time is taken as the best parameters ultimately.

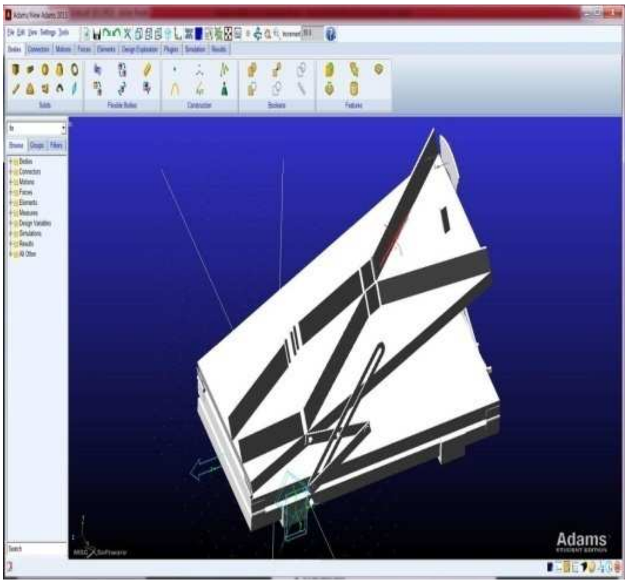

Figure 8: Trap Design using ADAMS/View

Figure 9: Frequency VS Magnitude Plot

Forced vibration analysis was conducted on the virtual prototype of the trap by setting up the appropriate input and output channels. From the analysis, the best frequency, trap angle, track angle and part motion time was obtained. Figure 9 shows the result of dynamic simulation analysis for track angle of 5^0, trap angle of 35^0 and part motion time of 68 sec. From this graph, the lowest magnitude will be attained for the best frequency of 58 Hz. Further increasing the trap

angle and track angle will make the part move (jump) out of the trap. After increasing the frequency to 65 Hz, the impact force introduced due to this the part motion time is also increased. Thus, as per the obtained frequency, track angle and trap angle, which are 58Hz, 5^0 and 35^0 respectively, they are concluded as the best values for a perfect and effective part motion

4.2. Real Time Experiment Results

A series of experiments were conducted on the experimental setup by varying the parameters like frequency, track angle and trap angle. The acceleration output obtained for different time period is shown in the figure 10. From this analysis, the part motion time was noted when parts move on the trap by using a stop watch.

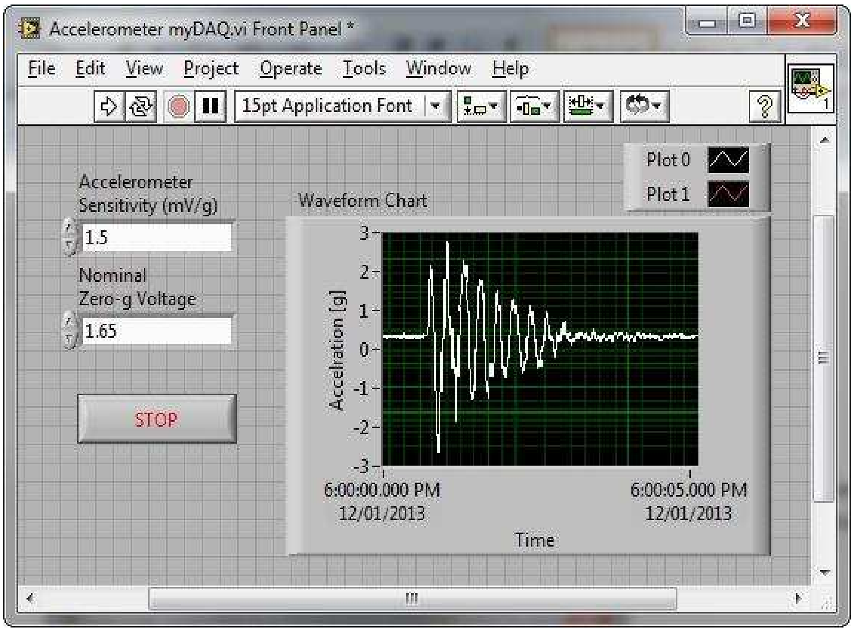

Figure 10: Acceleration Measurement using LabVIEW

Figure 11 shows that the frequency Vs times plot for track angle of 0^0. In this experiment, track angle was fixed as 0^0. The trap angle was varied 0^0, 5^0, 10^0, 15^0, upto 50^0. For each variation of the trap angle, frequency was varied 45Hz, 50Hz, 55Hz, 60Hz upto 90Hz. This frequency variation was repeated for each trap angle variation. This procedure is repeated for each track angle variation.

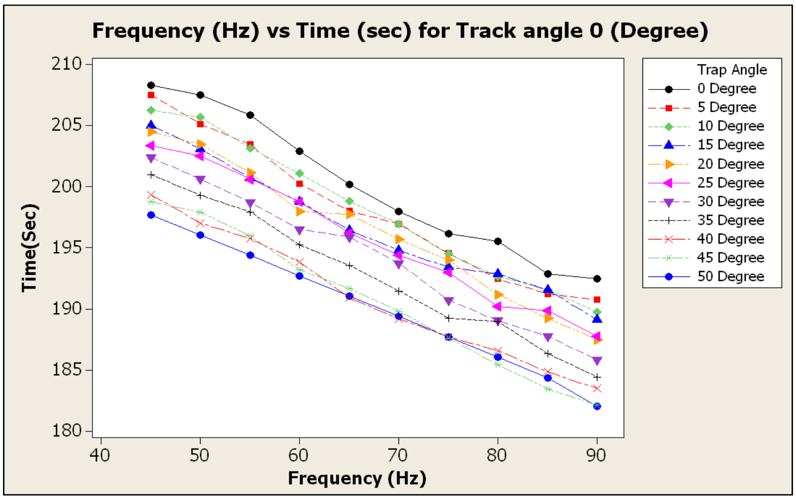

Figure 11: Frequency Vs Time Graph for Track Angle of 0^0

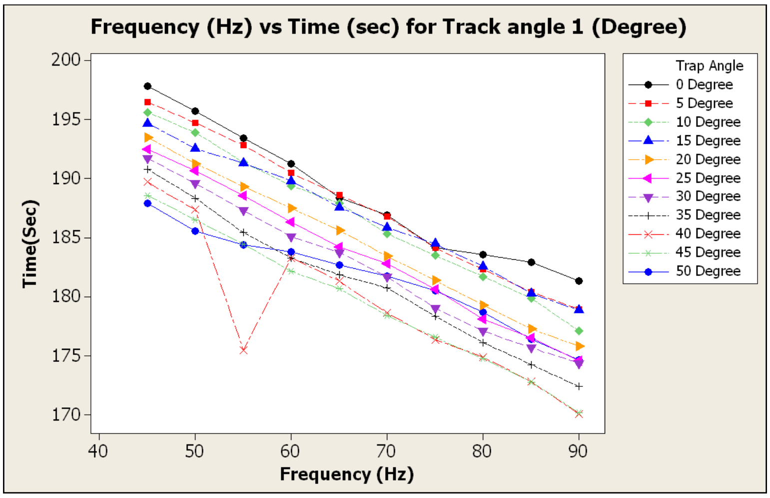

Figure 12: Frequency Vs Time Graph for Track Angle of 1^0

For 0^0track angle, from frequency of 50Hzto 70Hz, for trap angle of 30^0 to 50^0, the part motion time obtained was 200 sec to 182 sec. In this experiment, part motion time is too high. Figure 12 shows that the frequency Vs. times plot for track angle of 1^0. For 1^0 track angle, from frequency of 50Hz to 70Hz, for trap angle of 30^0 to 50^0, the part motion time obtained was 191 sec to 174 sec. In this experiment, part motion time is too high.

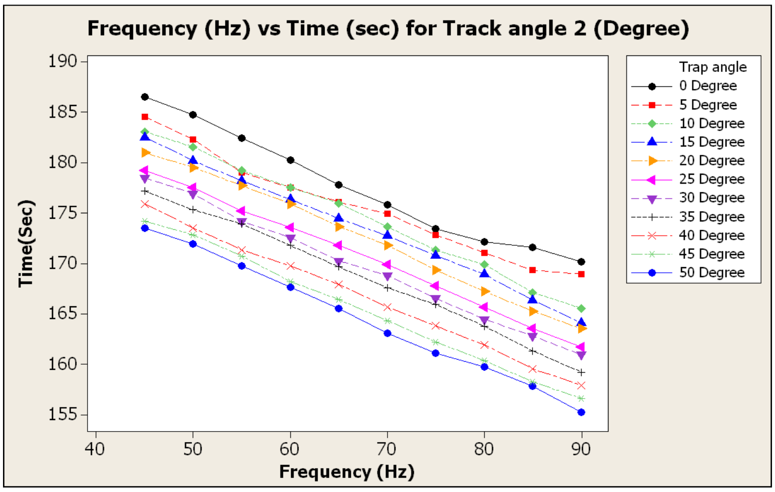

Figure 13: Frequency Vs Time Graph for Track Angle of 2^0

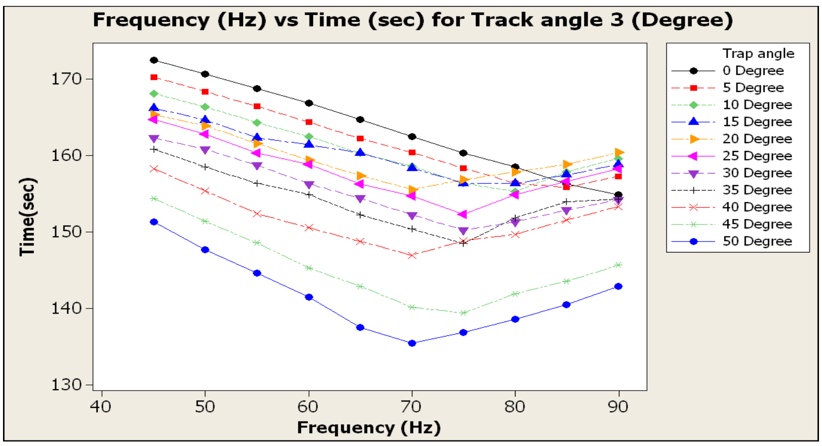

Figure 14: Frequency Vs Time Graph for Track Angle of 3^0

Figure 13 shows that the frequency Vs. times plot for track angle of 2^0. For 2^0 track angle, from frequency of 50Hz to 70Hz, for trap angle of 30^0 to 50^0, the part motion time obtained was 178 sec to 155 sec. In this experiment also the part motion time is high. Figure 14 shows that the frequency Vs. times plot for track angle of 3^0. For 3^0 track angle, from frequency of 50Hz to 70Hz, for trap angle of 30^0 to 50^0 the part motion time obtained was 162 sec to 142 sec. Part motion time is high in this case, too.

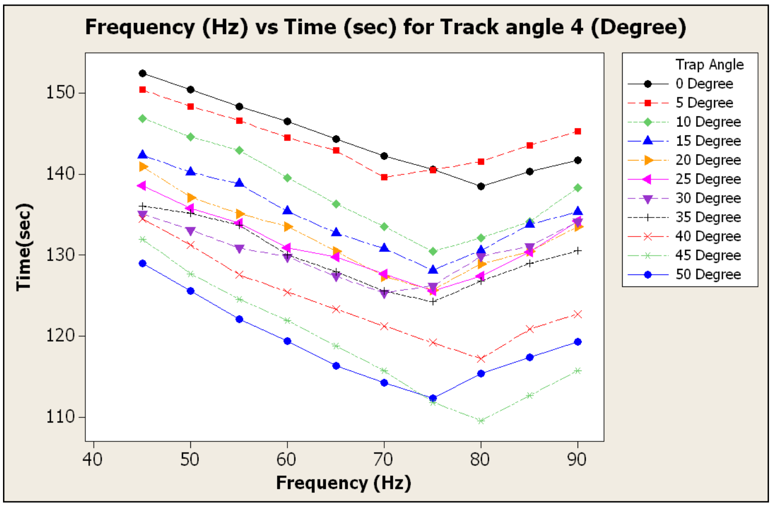

Figure 15: Frequency Vs Time Graph for Track Angle of 4^0

Figure 15 shows that the frequency Vs times plot for track angle of 4^0. For 4^0 track angle, from frequency of 50Hz to 65Hz, for trap angle of 30^0 to 45^0, the part motion time obtained was 135 sec to 114 sec. Here, the part motion time is relatively less. Figure 16 shows that the frequency Vs times plot for track angle of 5^0. For 5^0 track angle, from frequency of 55Hz to 65Hz for trap angle of 30^0 to 35^0, the part motion time obtained was 97 sec to 64 sec. This is the least part motion time. In 4^0 and 5^0 of track angle experiments, the frequency was increased above 65Hz, this in-turn induces impact force on trap. Due to this impact force, part motion time was increased. After increasing the track angle to 6^0 - 10^0 the part jumps out of the trap.

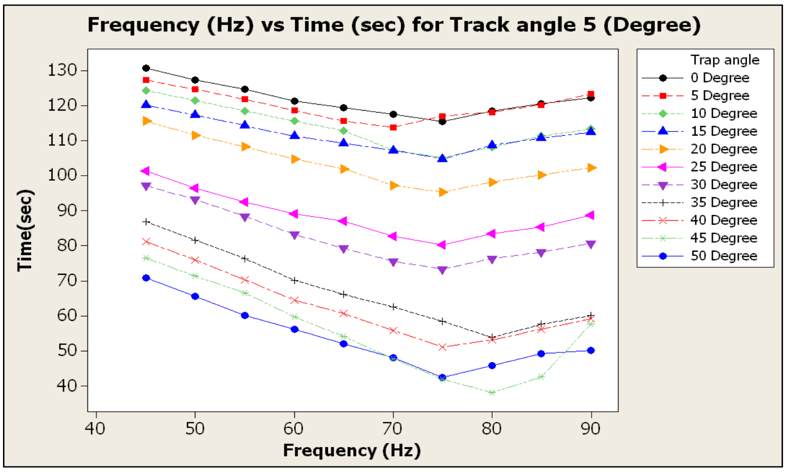

Figure 16: Frequency Vs Time Graph for Track Angle of 5^0

From this real time experimentation. Thus, as per the obtained frequency , track angle and trap angle, which are 60Hz, 50 and 35 respectively, they are concluded as the best values for a perfect and effective part motion. It is evident

from the graph that the best parameters for part motion at 64 sec and acceleration of 0.144mm/sec^{2}for 60Hz frequency, 5^0 track angle and trap angle of 35^0.

5. CONCLUSIONS

A functional virtual prototype of the trap was efficiently built using ADAMS software. Thus by using ADMS software, a functional virtual prototype of the trap system was built, on which the forced vibration analysis was conducted successfully. Various parameters such as 58Hz frequency, 5^0 track angle and 35^0 trap angle were found to be the best values for effective part motion from this dynamic simulation analysis. From the real time analysis which includes a series of experiments conducted by the use of Lab VIEW application on the experimental setup evidently proves that the frequency, track angle trap angle of 60Hz, 5^0 ,35^0 respectively are the best parameters. Thus, the conclusion derived from the results of both the multibody dynamics and the analysis using the LAB VIEW is that the best parameters for effective part motion is as follows, track and trap angle of 5^0 and 35^0 respectively and frequency of 58 to 60Hz. The similarity between the results of both the analysis i.e. real time and simulated experiments is seen from the comparision.

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